PATENT
Docket No.150.00650102

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

#15/Response
1/24/03

Applicant(s):	Vaartstra et al.	Group Art Unit:	2815
Serial No.:	09/603,132	Examiner:	E. Lee
Confirmation No.:	3538		
Filed:	June 23, 2000		

For: DEVICE STRUCTURES INCLUDING RUTHENIUM SILICIDE DIFFUSION BARRIER LAYERS

AMENDMENT AND RESPONSE UNDER 37 CFR §1.116

Assistant Commissioner for Patents
BOX AF
Washington D.C. 20231

Dear Sir:

The Office Action mailed November 25, 2002 has been received and reviewed. The two-month date for response was January 25, 2003. As January 25, 2003 was a Saturday, in accordance with 37 CFR §1.7, the two-month response date was extended to Monday January 27, 2003.

No claims have been amended or cancelled. Claims 27-44 are pending. Reconsideration and withdrawal of the rejections are respectfully requested.

The 35 U.S.C. §102 Rejection

The Examiner rejected claims 27-35 under 35 U.S.C. § 102(b) as being anticipated by Matsubara et al. (U.S. Patent No. 5,122,923).

Applicants traverse this rejection and submit that claims 27-35 are not anticipated by Matsubara et al. because such document does not teach each and every element of claims 27-35. For a claim to be anticipated under 35 U.S.C. § 102(b), each and every element of the claim must be found in a single prior art reference. *See* M.P.E.P. § 2131.

The Examiner has essentially repeated the rejection of claims 27-35 in the Office Action dated June 18, 2002. In response, Applicants respectfully repeat the arguments presented in their response to the June 18, 2002 Office Action filed on September 18, 2002. Applicants repeat those arguments below for the convenience of the Examiner. Applicants also provide additional support for the arguments presented in the instant response in the way of a declaration presented by the Applicants, Brain A. Vaartstra and Eugene Marsh, as discussed below.

As discussed in Applicants' response filed September 18, 2002, independent claims 27 and 32 recite a chemical vapor codeposited diffusion barrier layer. In contrast to claims 27 and 32, Matsubara et al. recites a thin-film capacitor with a silicon substrate, an insulating silicon oxide layer, a lower electrode, a dielectric layer of $BaTiO_3$ and an upper electrode of aluminum layer stacked in sequence from bottom to top (Col. 3, lines 42-47). The lower electrode layer is formed by a DC magnetron sputtering technique using a target of sintered Ru or $RuSi_2$ (Col. 3, lines 53-56).

Matsubara et al. fails to teach a semiconductor device structure that includes a chemical vapor codeposited diffusion barrier layer of $RuSi_x$ over at least a portion of a surface. In other words, Matsubara et al. describes a sputtered $RuSi_2$ electrode layer and not a chemical vapor codeposited diffusion barrier layer.

A chemical vapor deposited diffusion barrier layer according to the present invention is different than a sputtered layer such as described by Matsubara et al. For example, a sputtered layer, particularly with respect to high aspect ratio structures, provides different coverage thereon when compared to a chemical vapor deposited layer. For example, a sputtered layer at the edge of a contact hole tends to be particularly thick, reducing the opening of the holes disproportionately or, for example, sputtered material may not reach the bottom of the contact holes.

In contrast, a chemical vapor deposited film provides a highly conformal layer within deep contacts and other openings such as for lower electrodes of storage cell capacitors. *See* Specification, page 9, lines 15-17. These highly conformal layers relative to high aspect ratio structures are generally not possible with sputtering. Thus, the structures recited in claims 27-

35, including chemical vapor codeposited layers, are physically, structurally, and patentably distinct from those recited in Matsubara et al.

In support of this position, Applicants include with the instant response a "Declaration Under 37 C.F.R. §1.132" signed by the inventors that states, in part, that there are structural differences between a sputter coated diffusion barrier layer and a chemical vapor deposited diffusion barrier layer. These differences include, but are not limited to, different layer coverage on surfaces having complex geometries. For example, as discussed herein, sputter coating a contact hole having a high aspect ratio would typically result in a disproportionately thicker layer of material developing around the opening of the hole as compared to the other surfaces surrounding or within the hole. As a result, the sputter coated diffusion barrier layer may be unable to completely coat the walls and/or the bottom of the contact hole. This would leave regions of the contact hole either not coated or inadequately coated.

In contrast, chemical vapor deposited diffusion barrier layers provide highly conformal and uniform layer coverage on surfaces. This is especially true with respect to surfaces having complex geometries. As such, chemical vapor deposited diffusion barrier layers are more conformal and uniform on surfaces having complex geometries (e.g., contact holes) than a sputter coated diffusion barrier layer.

Additionally, structural differences between a sputter coated diffusion barrier layer and a chemical vapor deposited diffusion barrier layer also include differences in the resulting film and substrate qualities. For example, sputter coated diffusion barrier layers can have a high pinhole count as compared to chemical vapor deposited diffusion barrier layers. Also, there is limited stress control possible with sputter coated diffusion barrier layers as compared to chemical vapor deposited diffusion barrier layers.

In addition, an underlying substrate to a sputter coated diffusion barrier layer may have surface damage. This surface damage caused by the sputter coating technique may include implantation of metal into the underlying substrate. For example, ruthenium can be implanted into a silicon substrate surface during the sputter coating of $RuSi_x$. The implanted ruthenium can

then diffuse into the silicon substrate. In addition, silicon can be implanted into platinum surfaces during sputter coating of $RuSi_x$, where the silicon can diffuse into the platinum containing substrate. Either example of diffusion into the underlying substrate provides a structural difference between a sputter coated diffusion barrier layer and a chemical vapor deposited diffusion barrier layer.

As such, sputter coated diffusion barrier layers and chemical vapor deposited diffusion barrier layers have different structures. These differences are such that if a chemical vapor deposited diffusion barrier layer and a sputter coated diffusion barrier layer were analyzed by one skilled in the art they would be able to identify the diffusion barrier layer as either being a sputter coated diffusion barrier layer or a diffusion barrier layer having been deposited by a different technique (e.g., chemical vapor deposited diffusion barrier layer).

The Examiner alleges that the term "chemical vapor deposited" recites "a method of forming and does not deviate from the structure of a diffusion barrier made of $RuSi_x$." As a result, the Examiner gives no patentable weight to such term. Applicants traverse this allegation.

Applicants submit that the term "chemical vapor deposited" (which has been amended to recite "chemical vapor codeposited") is not a "product by process" limitation because the term describes the structure of the barrier layer. *See Hazani v. U.S. Int'l Trade Comm.*, 44 U.S.P.Q.2d 1358, 1363 (Fed. Cir. 2000) (holding that the limitation "chemically engraved" is not a product-by-process limitation). As stated above, a chemical vapor codeposited layer is different than a sputtered layer such as described by Matsubara et al. For example, a chemical vapor codeposited layer may be more conformal than a sputtered layer, especially when considering deep contacts and other openings. Further, a CVD codeposited layer may exhibit a more uniform distribution of ruthenium and silicide throughout the layer than a layer formed by sputtering or silicidation. Therefore, those skilled in the art would appreciate the structural differences between a chemical vapor codeposited layer and a sputtered layer. The words of a claim must be read as they would be interpreted by those of ordinary skill in the art. *See In re Sneed*, 218 U.S.P.Q. 385 (Fed. Cir. 1983). Because those skilled in the art would appreciate that

a chemical vapor deposited diffusion barrier layer is structurally different than a sputtered layer, the term "chemical vapor codeposited" is to be given patentable weight in the pending claims.

Claims 28-31 and 33-35, which depend, either directly or ultimately, from either claim 27 or 32, are not anticipated by Matsubara et al. for the same reasons as presented above for claims 27 and 32. In addition, claims 28-31 and 33-35 each provide additional elements that further support patentability when combined with claims 27 and 32.

For at least the above reasons, Applicants submit that claims 27-35 are not anticipated by Matsubara et al. Reconsideration and withdrawal of this rejection are, therefore, respectfully requested.

The Examiner also rejected claims 27-28, 30-33, and 36-44 under 35 U.S.C. § 102(b) as being anticipated by Kuroiwa et al. (U.S. Patent No. 6,239,460).

Applicants traverse this rejection and submit that claims 27-28, 30-33, and 36-44 are not anticipated by Kuroiwa et al. because such document does not teach each and every element of claims 27-28, 30-33, and 36-44.

The Examiner has essentially repeated the rejection of claims 27-28, 30-33, and 36-44 in the Office Action dated June 18, 2002. In response, Applicants respectfully repeat the arguments presented in their response to the June 18, 2002 Office Action filed on September 18, 2002. Applicants repeat those arguments below for the convenience of the Examiner. Applicants also provide additional support for the arguments presented in the instant response in the way of the "Declaration Under 37 C.F.R. §1.132" presented by the Applicants, Brain A. Vaartstra and Eugene Marsh, as discussed above.

For example, claims 27 and 32 each recite a chemical vapor codeposited diffusion barrier layer that is formed of $RuSi_x$, where x is in the range of about 0.01 to about 10. In contrast to claims 27 and 32, Kuroiwa et al. teaches a capacitor that includes a metal electrode 130 deposited on the top surface of a plug 111. *See* Kuroiwa et al., column 12, lines 26-29. In the embodiment of Kuroiwa et al. relied upon by the Examiner, a ruthenium silicide layer is formed by either sputtering or chemical vapor depositing a ruthenium layer on an already formed silicon

plug 111. *See* Kuroiwa et al., column 12, lines 35-36 and column 13, lines 7-18. Then a quick heat treatment is performed so that a portion of the metal electrode 130 is formed into a ruthenium silicide layer 132. This teaching of Kuroiwa et al. is in direct contrast to that described in amended claims 27 and 32 where the $RuSi_x$ is codeposited, i.e., the $RuSi_x$ is deposited by CVD using a ruthenium precursor and a silicon precursor.

One skilled in the art would understand that a codeposited $RuSi_x$ layer exhibits many differences over a ruthenium silicide layer formed by silicidation as taught by Kuroiwa et al. For example, a CVD codeposited $RuSi_x$ layer may include a more uniform distribution of silicon throughout the layer, whereas a silicidated ruthenium silicide layer may exhibit a gradient of silicon content from the ruthenium/silicon interface to the opposite surface of the ruthenium layer. Further, a silicidated ruthenium silicide layer may include uneven island formations of silicide instead of a more uniform $RuSi_x$ formed by CVD codeposition.

Further, for example, claim 36 recites an interconnect that includes a chemical vapor deposited diffusion barrier layer. An interconnect may include, for example, conductive layers in contact holes, vias, etc. *See* Specification, page 1, lines 13-14. In contrast to claim 36, the embodiment of Kuroiwa et al. relied upon by the Examiner teaches a capacitor structure. *See*, e.g., Office Action, page 2 ("Regarding claims 32, 33 and 36-44, Kuroiwa shows (*see*, for example, FIG. 10) a capacitor structure comprising metal electrode (first electrode) 130, capacitor dielectric 115 and upper electrode (second electrode) 116."). In other words, Kuroiwa et al. does not teach an interconnect that includes a chemical vapor deposited diffusion barrier layer.

Claims 28, 30-31, 33, and 37-44 each depend, either directly or ultimately, from one of claims 27, 32, and 36. As such, claims 28, 30-31, 33, and 37-44 are not anticipated by Kuroiwa et al. for the same reasons as presented above for claims 27, 32, and 36. In addition, claims 28, 30-31, 33, and 37-44 each recite additional elements that further support patentability when combined with claims 27, 32, and 36.

For at least the above reasons, Applicants submit that claims 27-28, 30-33, and 36-44 are not anticipated by Kuroiwa et al. Reconsideration and withdrawal of this rejection are, therefore, respectfully requested.

The Examiner also asserted that "[s]puttering and chemical vapor codepositing are two different methods used to form a same structure, in this case, a layer of $RuSi_x$." Applicants respectfully traverse this assertion. In response, Applicants have included a "Declaration Under 37 C.F.R. §1.132" from inventors Brain A. Vaartstra and Eugene P. Marsh with the present response. In the "Declaration Under 37 C.F.R. §1.132", the inventors state that there are significant structural differences between a sputter coated diffusion barrier layer and a chemical vapor deposited diffusion barrier layer. These differences are such that if a chemical vapor deposited diffusion barrier layer and a sputter coated diffusion barrier layer were analyzed by one skilled in the art they would be able to identify the diffusion barrier layer as either being a sputter coated diffusion barrier layer or a diffusion barrier layer having been deposited by a different technique (e.g., chemical vapor deposited diffusion barrier layer).

Summary

It is respectfully submitted that the pending claims 27-44 are in condition for allowance and notification to that effect is respectfully requested. The Examiner is invited to contact Applicants' Representatives, at the below-listed telephone number, if it is believed that prosecution of this application may be assisted thereby.

Respectfully submitted for
Micron Technology, Inc.

By
Mueting, Raasch & Gebhardt, P.A.
P.O. Box 581415
Minneapolis, MN 55458-1415
Phone: (612) 305-1220
Facsimile: (612) 305-1228
Customer Number 26813

26813

PATENT TRADEMARK OFFICE

27 Jan 2003
Date

By: _____

Mark J. Gebhardt
Reg. No. 35,518
Direct Dial (612)305-1216

CERTIFICATE UNDER 37 CFR § 1.8:
The undersigned hereby certifies that this paper is being transmitted by facsimile in accordance with 37 CFR §1.6(d) to the Patent and Trademark Office, addressed to Assistant Commissioner for Patents, Box AF, Washington, D.C. 20231, on this 27th day of January, 2003, at 3:05 pm (Central Time).

By: Sara E. Olson
Name: SARA E. OLSON